REMARKS

As noted above, Applicants hereby request that the finality of the rejection set out in the Office Action dated August 18, 2005 be withdrawn, and that the application be reconsidered in the light of the present response. The reason for this request is that originally-filed claims 10 - 15, which were rejected over the cited prior art in the first Office Action, were not amended in the Response filed on June 23, 2005; applicant simply pointed out that the rejection based on prior art was not supported by the references. The previous rejection was withdrawn in the present Office Action, and claims 10 - 15 were rejected over the newly-cited reference to Goto. This new ground of rejection was not based on amendments to claims 10-15, since there were none, so the assertions made in this regard in paragraph 10 of the Office Action are not supportable, and the final rejection is premature, as specified in M.P.E.P 706.07(a).

Withdrawal of the finality of the rejection, entry of the present response, and reconsideration and allowance of the application is, therefore, respectfully requested.

After careful review of the Office Action outstanding in this application, Applicants have amended claims 1, 6 and 7 to more clearly distinguish them over the art, and have added new claims 31-41 to provide the scope of protection to which they are believed entitled.

The present invention relates to a novel technique for producing unidirectionality in semiconductor photonic devices such as ring lasers and V-shaped lasers, based on the use of an etched gap or gaps in the laser waveguide. In addition, the present invention is directed to the formation of semiconductor lasers with at least one etched gap to enhance the side-mode suppression ratio. The invention is further directed to the

use of facets at or near the Brewster angle on photonic devices to prevent back-reflection.

In a preferred form of the invention, semiconductor lasers incorporate at least one gap which is provided by etching through the cavity of a ridge-type ring or V-shaped laser monolithically fabricated on the surface of a substrate. In another embodiment, semiconductor lasers incorporate at least one etched gap to enhance the side-mode suppression ratio. In another form of the invention, gaps may be etched in spaced-apart pairs, with the waveguide segment between the gaps being offset to compensate for refraction at the etched facets. In yet another form of the invention, when the laser output is coupled to a photonic device, back-reflection is minimized by providing a facet at the Brewster angle at a distal end of the photonic device.

In the Office Action, claims 1-4, 19-22 and 25-26 have been rejected under 35 U.S.C. 102(e) as being anticipated by Goto (6,839,376). In support of this ground of rejection, it is asserted that claim 1, for example, recites the features of Fig. 6 of the Goto reference. Thus, it is asserted that claim 6 recites a semiconductor laser cavity having three segments (10, 20 and 130) and an output, etched gaps extending through the segments, and a distributed Bragg reflector 23.

The Goto reference defines element 10 of Fig. 6 as a semiconductor laser chip, or more generally as a "semiconductor light emitting element for emitting a laser beam" (column 6, lines 23 and 24). Element 10 is more accurately described as a gain chip, not a semiconductor laser chip, since the description of this element indicates that it contains the features of a gain chip; namely AR coatings on the front facet 10b and the back facet 10a of the chip (see column 6, lines 33-35), and an oblique angled stripe 12

extending between the front and back facets (see column 6, lines 42 and 43). The entire device depicted in Fig. 6 of the Goto reference is an external resonator, more commonly known as an external cavity laser, which constitutes chip 10, a first wave length selector 20 (column 6, lines 47-51), and a second wavelength selector 130 (column 10, lines 27-30; column 11, lines 40-42).

As pointed out at column 4, lines 58+ of the patent, the laser light source 10 includes a stripe which is formed oblique to the end facet of the portion of the light emitting device that does not include the external resonators; that is, the chip 10. Because of this, when light traveling along the stripe is reflected at the oblique end facet, it is reflected in a direction differing from the traveling direction, with the result that the laser light source is oscillated only by the external resonator and is capable of emitting laser light (11) at a wavelength that is determined by the wavelength selector included in the external resonator. As pointed out in Goto at column 6, in the paragraph beginning at line 19, the facets on the light emitting element 10 in the Goto reference are cleaved, not etched, and thus follow the crystalline structure of the chip 10.

The present invention, as defined in claim 1, is directed to a semiconductor laser which includes a laser cavity having at least one segment and at least one output. There is an etched gap extending through the segment, and at least one distributed Bragg reflector at the output of the laser cavity. This claim defines over the reference to Goto in that the reference does not include an "etched gap" and does not include a distributed Bragg reflector "at said at least one output," features that are clearly and positively recited in the claim. The Office Action makes no mention of these elements of

the claim, and accordingly, claim 1 clearly defines over the reference under the terms of 35 U.S.C. 102(e).

In order to further distinguish over the reference, the claim is currently amended to define a "monolithic" semiconductor laser cavity. Such a structure is clearly not found in the Goto device; to the contrary, multiple discrete chips are used in th e reference device, with the chips being on different substrates. As a result, the Goto structure requires that the mode fields be matched between the various types of discrete chips (see column 11, lines 66 and 67; column 12 lines 1-3). The monolithic structure of the present invention clearly distinguishes over the teachings of the reference.

Furthermore, not only does the claimed invention differ over Goto in reciting an etched gap in a monolithic semiconductor laser cavity, but the claim defines a structure which cannot be fabricated through the teachings of Goto. This is particularly the case since Goto is not a monolithic laser cavity as now claimed.

Claims 2-4 are dependent on claim 1 and define over the reference for the reasons given above. It is again pointed out that the Goto reference does not have an etched gap; such a structure cannot be found anywhere in the reference. To the contrary, the Goto reference specifically uses cleaved facets, as noted above and as pointed out in the abstract, which states that "two cleaved end facets of the semiconductor light emitting device" are used. Cleaving only allows formation of facets that are along the cleavage planes of the semiconducting crystal and does not allow the formation of the devices described in the present application; etching allows a monolithic integration of devices that is not possible with cleaving. For example, the

monolithic structure of Figs. 1 and 2 of the present application cannot be fabricated through the use of cleaved facets.

There are significant differences between the etched gaps in a monolithic structure, as claimed herein, and the type of gaps that are formed between discrete devices such as those illustrated in the Goto reference. For example, the etched gaps in the claimed monolithic structure are determined and formed through lithographic techniques, while gaps formed between discrete devices are formed through mechanical manipulation and positioning of the devices to align their facets with respect to each other. Such mechanical positioning is inherently difficult, and accurately positioning cleaved facets to obtain the desired relationships and tolerances makes large scale manufacture of such devices difficult, at best.

Claims 19-22 are also dependent on claim 1 and distinguish over the reference to Goto for the reasons discussed above. Furthermore, claim 19 distinguishes over the reference in requiring multiple etched gaps along a single segment of the laser cavity. In the Goto device, there are three separate segments, each of a different material, with gaps between these separate segments. This is in contrast to the claimed invention, where there are multiple gaps in a single monolithic segment. There is no suggestion that such a feature could be provided in the Goto reference and there is no recognition in Goto of the advantages of such a structure, as defined in the present invention.

Claims 25 and 26 define over the Goto reference under 35 U.S.C. 102 for the reasons discussed above. Claim 25 defines a monolithic solid state waveguide cavity having an etched entrance facet and an etched exit facet, and such a structure is not disclosed, or even suggested, in Goto. The claim further defines an etched gap

extending through the solid state waveguide cavity between the entrance and exit facets, with the etched gap comprising a pair of parallel etched facets spaced apart by a length of between about .001 micrometers and 10 micrometers. Claim 26 adds multiple etched gaps.

The Office Action asserts that Goto discloses a solid state waveguide cavity having an etched entrance facet and an etched exit facet 11. However, as discussed above, Goto does not disclose etched facets, but specifically discloses cleaved facets, and accordingly the reference cannot anticipate this claim. It is further asserted in the Office Action that Goto discloses an etched gap extending through the solid state waveguide cavity between the entrance and exit facets. Here again, Goto does not disclose such feature, for it does not suggest or teach etched facets. In order to emphasize the distinction between claim 25 and the reference, this claim is amended to recite a monolithic solid state waveguide cavity, another feature not disclosed in Goto. Accordingly, the claim clearly distinguishes over the reference under the provisions of 35 U.S.C. 102.

Claim 26 is dependent on claim 25 and distinguishes over the reference for the reasons discussed above. In addition, the claim defines "multiple" etched gaps, and since the reference has no etched gaps, it cannot have multiple gaps and cannot anticipate the terms of this claim.

Claims 5, 7-12, 17, 18, 23, 24 and 27-29 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Goto in view of Spitzer (5,241,555). It is admitted in the Office Action that Goto does not disclose a ring-shaped laser, but it is asserted that Spitzer discloses a ring laser for use in a gyroscope. It is further asserted that it would

have been obvious to one of ordinary skill in the art to use the ring shape and Brewster angle orientation disclosed in Spitzer with the laser disclosed in Goto.

The patent to Spitzer discloses a semiconductor single crystal external ring resonator cavity 12 having a "plurality of reflecting surfaces defined by the planes of the crystal" to establish a closed optical path. A discrete laser medium is disposed on the semiconductor single crystal external ring resonator for generating coherent light in the cavity. The laser medium may be grown epitaxially on the semiconductor crystal and may be oriented at the Brewster's angle with respect to the optical path of the cavity to eliminate reflections and back scattering. More particularly, the reflecting surfaces of the external ring cavity of Spitzer are illustrated at 14, 16, 18 and 20, and establish a closed optical path. A laser 24 is positioned at the Brewster angle to the optical path, as described at column 5 of the patent, but there is no disclosure of a facet at the Brewster angle.

Rejected claim 5 of the present application is dependent on claim 1 and distinguishes over the Goto reference for the reasons discussed above. Claim 5 further defines the laser as being a ring laser having multiple segments joined end-to-end. The assertion in the Office Action that it "would have been obvious" to "use the ring shape and Brewster angle orientation disclosed in Spitzer with the laser disclosed in Goto" in order to obtain improved performance" is nothing more than a supposition that is unsupported by any teaching in either of the references.

The mere assertion of obviousness is not sufficient to support a rejection; there must be a teaching in the references that would lead to the combination defined in the claim, and no such teaching is found in either reference. Goto provides a single

wavelength output 11 at resonator 130 and makes no suggestion whatsoever as to how that function could be accomplished in a ring laser. There is no suggestion in Goto that the laser element 10 should be at a Brewster angle orientation with respect to the resonators 20 and 130 (which would be required if the teachings of Spitzer were to be followed) and no suggestion as to what result would be obtained if that were to be accomplished. To the contrary, Goto provides anti-reflective coatings at facets 10a and 10b as well as 20a and 130b in order to provide its specific construction and operation, and there is no teaching in the reference that such features could or should be used in a ring laser.

The ring resonator of Spitzer is energized by light from a separate laser 24 which supplies light at Brewster's angle to prevent reflection. But there is no suggestion that the ring itself should be a laser, nor is there any teaching in that reference that any segments of a ring laser should incorporate etched gaps. In addition, there is no teaching in either reference as to how a ring laser would function with etched gaps and no teaching, or even a suggestion, of the advantages described in the present application as being obtained by Applicants' structure. The teachings of the two references fail to disclose how the device of Goto could be made into a ring and still achieve the functions described and claimed by Goto, contrary to the assertions in the Office Action. Since the combination asserted in the Office Action cannot be supported by the actual teachings of the references, claim 5 is clearly allowable.

With respect to claim 7, it is asserted that Goto discloses a semiconductor laser cavity having three segments and an output, with an etched gap extending through the segments and a photonic device connected to the output of the laser. As previously

pointed out, Goto fails to disclose etched gaps and is not a monolithic semiconductor laser cavity, as recited in the claim. The Office Action rightly points out that Goto does not disclose an etched facet at the Brewster angle but asserts that in Fig. 9 of Spitzer, a facet 16 at the Brewster angle is used "to eliminate reflections" at one end of a photonic device 78.

Contrary to the assertions in the Office Action, Spitzer does not disclose the features ascribed to it. The facet 16 is not described at column 3, lines 13-16; to the contrary, that section of the Spitzer specification describes a laser medium oriented at Brewster's angle with respect to the optical path of the laser cavity. This Brewster's angle orientation is further described at column 5, lines 34-36, but in neither place does the reference discuss a facet at the Brewster angle. Furthermore, the facet 16 of Spitzer is not formed at one end of a photonic device 78, as asserted in the Office Action, but instead is a totally internally reflective facet which is formed as part of the ring 12 (column 5, beginning at line 23). Accordinly this claim is clearly patentable over the references.

Claims 8 and 9 are dependent on claim 7, and distinguish over the combined references of Goto and Spitzer for the reasons discussed above.

Claim 10 is an independent claim which is distinct from the references for the reasons given above; namely, that there is no disclosure in either reference of the claimed etched facet at or near the Brewster angle at one end of a photonic device cavity segment.

Claims 11 and 12 are dependent on claims 10 and claim 29 is dependent on claim 25. These claims distinguish over the references for the reasons discussed above.

Claim 17 is dependent on claim 5 and defines a semiconductor laser having a monolithic cavity with one segment that incorporates multiple etched gaps. It is asserted in the Office Action that the three segments disclosed in Fig. 6 of Goto "incorporate multiple etched gaps". Applicant's respectfully disagree with this assertion and point out that Goto is neither monolithic nor includes etched gaps, and does not show gaps extending "through the three segments" but rather shows gaps which separate the three segments. These are distinct segments, not monolithic, as discussed above, and the existence of gaps between such separate segments does not meet the terms of the claim, which requires multiple gaps "through said at least one segment".

With respect to claim 18, it is asserted in the Office Action that "the gaps disclosed in Fig. 6 of Goto are spaced-apart etched facets". Applicants respectfully disagree; there is no teaching in Goto of "spaced-apart etched facets".

Claim 23 is dependent on claim 1 and defines each facet as being angled with respect to the length of the segment. Although Fig. 9 of Spitzer discloses a facet 16 that is angled with respect to the length of a segment, that facet is not part of a gap, and there is no teaching that it should be. Therefore, Spitzer cannot teach angled gaps for Goto. More particularly, the totally internally reflective facet 16 of Spitzer cannot teach a modification of Goto's facets 10a, 20a, 10b and 130b since none of them are totally internally reflective.

With respect to claim 24, it is asserted in the Office Action that the segment 10 of Goto "is offset from adjoining segments to compensate for the refraction of light at the interfaces". Claim 24 is dependent on claim 23 and defines the length of the segment to be offset from adjoining segments to compensate for the refraction. Although the Goto reference describes Snell's law being satisfied between the discrete chips, it does not teach a monolithic structure with etched gaps to accomplish this. Accordingly, claim 24 is distinct from the teachings of the references.

With respect to claim 27, it is asserted that Fig. 9 of Spitzer discloses gaps that are angled. However, applicant is unable to find any gaps in Spitzer much less gaps that are angled. Spitzer discloses four totally internally reflective facets, but these are not gaps. Accordingly, the Spitzer reference cannot teach angled gaps for the Goto device, contrary to the assertion in the Office Action.

Claim 28 is dependent on claim 25 and distinguishes over the Goto reference for the reasons discussed above. Claim 28 further defines the device of claim 25 as including multiple etched gaps spaced along the waveguide cavity (claim 26) and defines the waveguide cavity as being a ring laser. As discussed above, there is no teaching whatsoever in Goto that the three segments disclosed in the reference could be formed into a ring laser, nor is there any suggestion of the advantages of so doing. Certainly Spitzer does not provide such a teaching, for although Spitzer is a ring laser, there is no suggestion that any advantages would be obtained by providing etched gaps passing completely through the waveguide cavity between entrance and exit facets. In the absence of such a teaching in Spitzer, its combination with Goto cannot produce

such a structure. Accordingly, claim 28 is clearly patentable over the combined teachings of these references.

Claims 6 and 30 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Goto in view of Zoll et al. (5,848,090) it being asserted that Fig. 2 of Zoll "discloses a V-shaped laser (10) to produce a non-linear light path," and further asserts that it "would have been obvious" to form the laser disclosed in Goto in "a V-shape as disclosed in Zoll for improved device stability and reliability".

The patent to Zoll discloses a V-shaped resonator which has first and second channels for receiving a laser beam. The resonator includes adjustable mirrors fixed to the housing so that the resonator can be transported and installed. There is no teaching in this reference that would suggest that the three segments of the Goto device could be formed in a V-shape, for Zoll itself does not disclose a V-shaped laser. To the contrary, Zoll discloses two channels diverging from a common input, as illustrated in Fig. 1 of the Zoll patent, where a laser 1 supplies light through a filter 4 to the two cavities 9 and 10, with the channel 9 incorporating a sample which is to be monitored. This is not a teaching of a V-shaped laser.

Zoll can not suggest that the Goto device could be fabricated in a V-shape for the additional reason that there is no teaching in Zoll as to how that could be accomplished without destroying the entire purpose and function of the Goto invention. The Goto device shows a laser 10 located between resonant cavities 20 and 130, and this is directly contrary to the structure of the Zoll device, which discloses a laser 1 that is located outside both of the cavities. Such a structure does not teach how the Goto device can be modified to meet either claim 6 or claim 30. If one were to try to reposition

the three segments of Goto into a V-shape as suggested by the Office Action, Applicants inquire where the two ends 10a and 10b of the laser chip would be positioned with respect to the two ends of segments 20 and 130 to accomplish a V shape, and how such a structure would maintain the specified function of the Goto device. It is respectfully submitted that the references in fact do not suggest how such a reconfiguration of Goto could be accomplished to produce an operational device, and do not suggest what the operation would be. Any attempt to restructure Goto in the manner suggested in the Office Action would destroy Goto, and would not result in the claimed invention.

In the Office Action, claims 13-15 have been rejected under 35 U.S.C. 103 as being unpatentable over Goto in view of Spitzer, further in view of Zoll. It is admitted in the Office Action that neither Goto nor Spitzer discloses a V-shaped laser, but it is asserted that it would be "obvious to one of ordinary skill" to form the laser of Goto and Spitzer in a V-shaped "as disclosed in Zoll".

Claim 13 is dependent on claim 10 and defines over the references for the reasons already discussed. This claim defines the photonic device as having a V-shaped structure with at least one segment including a first and a second leg. As pointed out above, Zoll does not suggest that a ring laser such as that of Spitzer could be V-shaped, nor does it suggest that Goto could be in a V-shape, particularly if Goto is modified by Spitzer. The assertion in the Office Action that the formation of the Goto and Spitzer devices in a V-shape would improve device stability and reliability is simply without support in the references, for neither reference makes such a suggestion. Obviously, the Office Action relies solely on Applicants' disclosure for this conclusion.

Claim 14 defines the device of claim 13 as further including an etched facet near the Brewster angle at an end of a first leg of a V-shaped structure. There is no teaching of such a feature in either Goto, Spitzer, or Zoll, and accordingly the combination of these references cannot provide such a teaching. As discussed above, Spitzer does not disclose the use of a facet at a Brewster angle in a ring laser, but only discloses a laser source on a ring cavity with the source at Brewster's angle with respect to the ring. Zoll shows an input port leading to two diverging channels, and has no suggestion that an etched facet should be provided at the Brewster angle on either end of that structure. The patent to Goto does not suggest any facet at the Brewster angle, and accordingly no combination of these references can produce the claimed invention.

Claim 15 is directed to a photonic device in which the first and second legs are joined at corresponding ends to form the V-shaped structure, with an exit facet positioned at the joint. The Office Action asserts that Zoll discloses first and second legs joined at corresponding ends to form a V-shaped structure with an exit facet 26 being positioned at the joint of the first and second legs and refers to column 4 lines 49-52 of Zoll.

A reading of the Zoll patent reveals that the element 26 in fact is not an exit facet, but is an opening in front of which an input/output coupler mirror is arranged. This coupling mirror permits an input from laser 1 to enter the two channels 9 and 10, and thus is clearly not the claimed exit facet. Accordingly, the combination of references asserted in the Office Action clearly cannot produce the claimed invention.

It is respectfully submitted that the references, taken singly or in combination, cannot teach the invention set forth in the claims of the present application under either

35 U.S.C. 102 or 103, for the references clearly have no teachings that would support such rejections. It appears that all of the grounds of rejection are based on Applicants' own disclosure, with the references being selected in accordance with Applicants' teachings, not in accordance with the teachings of the references themselves. Accordingly, reconsideration and allowance of the claims is requested.

New claims 31-41 have been added to provide additional coverage for the invention described herein. These claims are all dependent on claim 1, and thus define over the references for the reasons discussed above. Furthermore, additional features of the invention are recited in these claims to further and clearly define over the cited references. These claims are believed to be clearly in condition for allowance.

As noted above, it is respectfully submitted that the final rejection in this application was clearly premature and should be withdrawn. The present amendments to the claims clarify and further define over the references and the newly added claims explicitly cover features that were implicitly covered by the previous claims. Since they are dependent on claim 1, which is believed to be allowable, these claims also are clearly allowable. Favorable reconsideration is respectfully solicited.

Respectfully Submitted,
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